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Comparative Research in Recent Times, Various Designs and Functionalities in Various Operating Systems

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Abstract*: This study provides a comparative analysis of three well-known operating systems: Windows, Linux, and Macintosh. The most important factors to consider when studying them are memory and file management, architecture, security, versatility, and other themes. This study compares and contrasts these subjects. This research study provides an outline of the major subjects as well as the different similarities and variances in operating system fundamentals. Every operating system has its own set of differences in terms of composition and structure, and this research focuses on the operating system's fundamental strengths and shortcomings.Linux, Windows, Mac, UI, Architecture, File Management, and Security are some of the terms used in this article.*

1. Introduction

The operating system is a piece of software that serves as a link between a computer's user and the hardware system, as well as managing and coordinating hardware usage among several applications and users. It is a set of programs that aid in the management of hardware resources and provide common functions for computer programs. It is one of the most important components of a computer. Process generation, Processing state, Process synchronization, Process communication, and Deadlock avoidance are the five major tasks of an operating system. Applications require an operating system (OS) to run, and the computer itself requires an OS to keep the system secure and provide a GUI/CLI interface for users to access and do operations on. To aid comprehension, a tabular comparison of three operating systems is offered after each feature. Real-Time Operating System (RTOS), Single-user single task, single-user multi-tasking, and multi-user are the four primary types of operating systems among the many distinct varieties. Control machinery, research instruments, and industrial systems all employ RTOS. Because the system will be offered as a "sealed box," an RTOS will likely have limited user interface capabilities and no end-user tools. Single-user, single-task design systems are used to allow a single user to successfully operate the system. It's primarily utilized for mobile devices. Single-user multitasking allows a single user to conduct or run multiple programs at once.

This is the operating system that is most typically found on desktops and laptops. This type of operating system includes Windows and Mac OS.A multi-user operating system allows numerous users to consume resources in a balanced fashion at the same time. It ensures that there are enough resources to ensure that none of the active users are inconvenienced. UNIX, VMS, and mainframe OS are all examples of multi-user operating systems. Linux is a widely used operating system that is used not only in personal computers but also in supercomputers and data centers around the world. Because of its various security and flexibility features, it has supplanted Windows and Mac OS. Anyone can use and alter the system to their taste, and it is the basis for a vast number of distributions. Windows is a Microsoft operating system that was released in its initial version on November 20, 1985. It's based on the Disk Operating System (DOS), which is famous for its black screen and command prompt. Following the debut of Windows 95, Microsoft began to dominate the market. This was due to the fact that Windows 95 was the first operating system to feature a Graphical User Interface (GUI) in the front and DOS in the back. For a non-computer person, this was a true revolution.

Apple Inc. created the Mac operating system in 1984. The Motorola PowerPC Chip, which is set with an advanced architecture optimized for graphics and multimedia interface and usability, was utilised in Macintosh computers. The Macintosh operating systems were all GUI-based, with no command-line options. The Apple

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Mac series of computers has been Intel-based since 2005, but the Mac OS, the first multitasking operating system, is only licensed to run on an Apple Mac. Because of its UNIX roots, Mac OS X allows us to use a character-based interface. Apple is the only company that makes Macintosh computers.

TABLE I. COMPARISON OF OS BASIC FEATURES

Linux	Windows	MacOS
In 1991, a Finnish university released the film. Designed mostly for GNU developers. It was later merged into Linux.	It was planned to be a Graphical User Interface (GUI) on top of MS-DOS when it was released in 1985. Later, when Windows 95 was released, all of the functions were merged. This was a commercial revolution of sorts.	It is the oldest out of the three and was released in 1984. From the beginning, it was a Graphical User Interface (GUI). Later in 2005, its design and architecture were changed to Intel x86 based architecture.

2. LINUX Versus WINDOW Versus MACINTOSH

2.1 Booting Process

It is the initial step that occurs when we turn on a computer or a process that occurs when a computer is turned on. It can be accomplished using both hardware (by pressing the start button) and software (by issuing a command).

LINUX - There are six steps to the booting procedure. The basic Input/Output system executes the MBR (Master Boot Record) first. The MBR then runs the Grand Unified Bootloader (GRB). After that, GRB executes the kernel. The kernel then executes /sbin /init. Init then executes run level programs, which are then executed from the command line.

WINDOWS - A cold boot begins the booting process when the machine is turned on. When you turn on your computer, it runs a Power On Self Test (POST). The MBR is sought in the bootable device. The MBR is now used to locate the boot sector and BOOTMGR. BOOTMGR looks for an active partition and reads the BCD file from the active partition's boot directory. Winloader loads drivers and sets them to start at boot, after which control is passed to the Windows kernel.

MAC-The OF or EFI code is executed here when the power is turned on. After that, all hardware information is gathered and initialised. The boot loader now has control of the system. BOOTX loads the kernel and, if applicable, the OS badges. The routine kernel is now being executed. Firmware is no longer accessible because the root device of the booting system has been discovered. Following that, the I/O kit is initialised, and the kernel is started.

TABLE II. COMPARISON OF VARIOUS OS BOOTING PROCESSES

OS Features	Windows	Linux	MAC
BIOS	Yes	Yes	No
POST	Yes	Yes	Yes
Boot Loader	NLTDR	GRUB or LILO	BOOTX
Kernel	NTOSKERNEL	INIT	Mach_init

The POST step is the same in all three operating systems. This investigation also reveals that, of the three operating systems, Mac is the only one that does not use BIOS and instead uses BootROM, which includes a boot loader named BootX or Boot. Efi

2.2 Information on the User Interface

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The part of an operating system that allows users to enter and edit data is known as the user interface. In other words, it serves as a communication channel between users and the operating system.

LINUX is a free operating system. You can utilise both the GUI and the CLI in Linux. Although the CLI appears to be superior to the GUI, this is not the case. CLI can never be used to edit movies, and a graphical audio player is considerably more likely to be used to create playlists, for example. A graphical user interface is also plainly required for image editing.

MAC OS - "AQUA" is the name of Apple's graphical user interface and visual motif. Its original theme was 'water,' and it included droplet-like elements as well as reflection and translucency motifs. Its goal in macOS applications is to "incorporate colour, depth, and sophisticated textures into a visually pleasing interface." Figure 5 depicts the various user interfaces for the three operating systems and how they compare to one another. Clearly, each of the three has its own aesthetic and provides a pleasant user experience.

WINDOWS- Because the Graphical User Interface (GUI) is an essential part of Windows, it cannot be replaced. A command shell programme (cmd) can also be run directly. Programs are run in distinct "windows," as the name implies. Because each application runs in its own window, we can have multiple programmes running at the same time. For home computers, this is the most prevalent operating system. Windows 10 is the most recent version of the operating system.

2.3 Managing System Assets

Troubleshooting requires constant monitoring of system resources such as memory, mass storage, network connectivity, and the processor.

LINUX is a free operating system. In Linux, the 'TOP' command aids in the monitoring of programmes, which is frequently used by administrators to keep track of system performance. This command keeps a running and active realtime processes list, which is updated on a regular basis. It may show CPU use, RAM consumption, swap memory, cache size, buffer size, process pid, user, and instructions, among other things. The command 'Vmstat' then displays information about virtual memory, system processes, drives, I/O blocks, interrupts, and CPU activity, among other things. The command 'lsof' displays a list of all open files and processes.

WINDOWS - When a software in Windows requires hardware resources, it sends a request to the operating system. The appropriate software is then provided by Windows in response to the request. The simplest approach to keep track of resources in Windows is to open the Task Manager window from the Performance Tab, as shown in Figure 6. Ctrl+Shift+Esc is the shortcut for opening this window. Here we can check how much CPU and RAM is being used.

MAC OS - The 'Activity Monitor' in Mac OS displays the processes that are now running on our system. We can control resources and see how Mac's activity and performance can be evaluated this way. As seen in figure 7, we may either find it using 'Spotlight' or open it from the Utilities folder of Application. Activity Monitor displays programs that are not visible, such as user apps, system apps utilized by Mac OS, and background processes.

2.4 File Administration

One of the most fundamental but crucial functions of an operating system is file management. It can handle a wide range of file formats and extensions. It has the ability to create, update, and delete files.

LINUX FILE SYSTEMS - Linux file systems describe how Linux computers organize, store, and track system files. The file system is essentially a collection of directories or folders that act as placeholders for the locations of other files. Under other words, in the Linux file system, there is no distinction between a file and a directory, because a directory is regarded a file with the names of other files. As a result, files include software programs, services, messages, photographs, and so on.

In the same way, according to the file system, input and output devices are considered files. It also includes the namespace, which contains the naming standard for naming files in terms of length and character combinations. It also comprises the organizational framework, which is the logical structure of the files on disc, which is commonly organized using folders in a hierarchical manner.

WINDOWS- In Windows, the 'Windows Explorer' program handles file management. It displays a list of our computer's files, directories, and hard discs. When a file needs to be copied, for example, we open the folder containing the file to be copied or relocated, then drag and drop the file to the appropriate folder or disc. The following instructions will open Windows Explorer: 1. Go to Start->All Programs->Accessories->Windows Explorer

MAC OS - To organise and manage our files, we use 'FINDER.' Finder, in conjunction with tools like Automator, may assist users in finding documents, searching for files, managing folders, and organising them. Press the "Command" and "N" keys at the same time. Apple's proprietary file system is APFS (Apple File System). The Apple File System is largely concerned with encryption, as well as flash and solid-state drive optimization. storage. It uses inode numbers that are 64 bits long. For better space management and efficiency, the APFS uses commands like TRIM. Apple File System uses checksums to maintain metadata data integrity.

2.5 Device Administration

It is the act of device drivers and device controllers collaborating between computer devices. It's used to keep track of hardware, storage, and input/output devices. It monitors the status of all connected devices to a computer.

LINUX is a free operating system. Only a few devices are still compatible with the Linux operating system. Hardware devices that are compatible but not supported, on the other hand, function on all versions of Linux. Linux is also a developer-friendly operating system that allows developers from all around the world to contribute to its database. Linux is widely utilised in non-mobile telecommunication networks due to its low cost and ease of customization. Linux is also used by the majority of customer premises equipment and embedded systems.

WINDOWS - Device management is a Control Panel applet in Windows OS that allows users to view and control the computer's hardware. It allows all apps and system features to be notified in a consistent manner of any changes that may affect their operation or access to resources. It also enables us to update and reinstall individual device drivers.

MAC OS - Thanks to its multi-layered secure basis, Apple devices can not only safely access network services but also protect vital data. The mobile device management (MDM) solution for iOS and macOS enforces a passcode and password policy, ensuring security. If an Apple device falls into the wrong hands, a remote command can be performed with the help of a user or an administrator to erase all private information. The following steps can be taken to create a safe computing platform for Apple devices:

i) Techniques are used to prevent illegal use of gadgets.
ii) Data protection at rest, in the event that the device is stolen or lost.
iii) Adherence to networking protocols and data encryption during transmission
iv) Apps run safely without jeopardizing the platform's integrity.

These features work together to create a safe computer environment.

2.6 Safety and security

It is the process of putting in place methods to protect an operating system both externally and internally. This is mostly accomplished through assuring the operating system's integrity, confidentiality, and availability.

LINUX is a free operating system. Although Linux OS is known for having stronger security than other operating systems, most distributions are still vulnerable to some attacks since they are designed with privacy, information security, and anonymity in mind. Linux OS is still subject to viruses that can be downloaded from the internet, similar to the threats that most PCs face. Basic security measures, such as virus scanning, firewalls, and file permissions, can help prevent this.

WINDOWS- Microsoft Windows is the most widely used consumer operating system in the world, and this is why. Many office contexts adopt it as a norm. However, because of its popularity, it is a target for viruses. Users and the security community do not have access to the source code of Windows because it is a closed source operating system. [8] As a result, we can select privacy-protecting features while installing Windows: - i) We must accept 'Express settings' while installing Windows; otherwise we can just click on Customize settings.

ii) Then, on the initial Customize settings page, we must enable all of the options.
iii) Select 'NEXT' to go to the next step of customizing options.
iv) On the second Customize Settings screen, click the "Exit" button. Use the Smart Screen online service to assist defend against harmful material and downloads on websites loaded by Windows browsers and Store apps that have been activated, as this will improve security. To alter the remaining options to 'off,' click 'on'.
v) Then we must proceed with the Windows installation.

MAC OS- The MAC operating system is distinct from the rest because it was created particularly for Apple devices. There is no such thing as a third-party developer. As a result, MAC is surrounded by a powerful shield that protects it from malware and viruses. In addition, MAC allows the user to acknowledge a file while it is being executed. Apple publishes Mac OS updates on a regular basis to improve security.

2.7 Flexibility

A versatile operating system allows the user to run many programmes and do various tasks at the same time. It allows the user to customise and adapt the system to their preferences.

LINUX - The most significant advantage of Linux is the user's flexibility to customise the distribution to their preferences, particularly on the desktop.

Because the operating system is open source, it is simple to use and allows the user to personalize it to their liking and comfort. The majority of linux distributions is adaptable enough to function on a wide range of devices (including mobile phones) and is stable enough for mission-critical applications.

WINDOWS- Since 1985, when it was first released, Windows has evolved significantly. It can be used for a variety of things. Windows 10 has been redesigned to better protect data from security attacks. Windows Hello is a password-free sign-in service that allows users to access their devices without having to remember their passwords. A number of new security features, including as fingerprint and face unlock, have been included. Device Guard protects intellectual property as well. Windows 10 has recently been updated to include new features such as Windows Ink, Windows Edge, and Cortana.

Windows 10 is available in four different versions:

i) Windows Pro ii) Windows Home iii) Windows Enterprise iv) Windows Education.

3.Conclusions

As a result, the operating system serves as a conduit between users and computer hardware. On the basis of some features, we compared operating systems such as Linux, Windows, and Mac OS in this article. As a result of our comparison, we can conclude that none of them are particularly bad. Each has its own set of benefits and drawbacks. Our goal is to provide consumers with an overview that will assist them in selecting an operating system that best suits their needs.

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